I. Project Title: Green and Yampa River Basin Sediment Monitoring Program

II. Principal Investigator:

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III. Project Summary:

The Recovery Program has identified a need to better define the requirements, appropriate methodologies, and levels of effort for a sediment monitoring program, to help define habitat requirements for endangered fishes in the Yampa, Little Snake, and Green rivers. To meet that need, an independent peer review panel was formed to review historical data, review the status of ongoing data collection efforts, identify sediment issues as they relate to recovery of endangered fishes, and develop recommendations for future sediment work to support Recovery Program efforts. Based upon peer review recommendations, an initiative to collect sediment data was started in 1998. During 1998, 25 suspended sediment and bedload samples were collected at the two Yampa River sites and one Green River site between May 6 and June 30, 1998. The data were published in Water Resources Data for Colorado, 1998 vol. 2 (Water-Data Report Co-98-2). During the second year of data collection (1999), 14 samples were collected at the two Yampa River sites and the Green River site between March 31 and June 24. In addition, 18 suspended and bedload samples were collected on the Green River above Canyon of Lodore during varied reservoir releases from Flaming Gorge under the scope of work for a separate project.

IV. Study Schedule: Initial year - 1998, Final year - 2008

V. Relationship to RIPRAP:

Yampa River Action Plan: Yampa and Little Snake Rivers1.A.4.a(3)
Yampa River Operation and Management Plan

VI. Accomplishments of FY 2001 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Sediment sampling continued at five gaged sites in the study area in Water Year 2001 and an interpretive report based on data collected through Water Year 2000 was prepared and reviewed. Below is a summary of data collected from March through June 2001:

Station Name	Suspended samples	Bedload samples
Yampa R. above Little Snake	7	7
Little Snake R. near Lily	8	6
Yampa River at Deerlodge Park	4	4
Green R. above Gates of Lodore	5	5
Green R. near Jensen	5	5

The sediment samples from WY 2001 were not included in the analyses or the interpretive report because the report was prepared before 2001 laboratory results were available. WY 2001 and future data will continue to be archived in the USGS data base.

The interpretive report was prepared for publication as a U.S. Geological Survey Water-Resources Investigations Report. A draft of the report was reviewed by two USGS colleague reviewers and a USGS editor. In addition, the report draft was submitted to the U.S. Fish and Wildlife Service for review by members of the Recovery Program for Endangered Fish in the Upper Colorado River. Comments from two reviewers from the Recovery Program were received in November. All review and editorial comments are being incorporated into the final draft of the interpretive report. The revised report will be submitted to the USGS Regional Hydrologist for a final review in December 2001. It is anticipated that the final USGS Director's approval and printing will be completed in early calendar year 2002. Printed copies of the report will be available to the public from the USGS and the USFWS.

The Summary and Conclusions sections from a draft of the interpretive report are reproduced below.

SUMMARY AND CONCLUSIONS

Large amounts of sediment are stored in the lower Little Snake, lower Yampa, and lower Green Rivers in the form of alluvial banks, bars, and islands. These near-channel areas may be important secondary sources of sediment that periodically is entrained by the Green River and its larger tributaries. 1988 aerial photographs of the channels of the Little Snake River below the Lily streamgage, the Yampa River below Cross Mountain, and the Green River from the Ladore Ranger Station to Jensen were assessed to determine the relative abundance of alluvial materials in the banks and bars. The relative abundance of subaerial alluvial deposits in the photographs varied from river to river in the watershed and from subreach to subreach along a river. Although the flood-plain width was relatively narrow and the surface area of alluvial deposits was small, the Little Snake River a few miles downstream from streamflow gaging station 09260000 had a very high percentage of alluvial material along its boundaries

The large sediment yield of the Little Snake River is reflected in the increase in relative abundance of alluvial deposits in the Yampa River immediately downstream from the Little Snake River confluence. The relative abundance of alluvial material drops abruptly from greater than 80 percent to less than 20 percent as the Yampa River flows into the steep and narrow Yampa Canyon. Alluvial deposits are relatively scarce in Yampa

Canyon between River Miles 45 and 21. The canyon geomorphology in this reach is dominated by the massive Morgan Limestone and the river is steep and the canyon floor is narrow providing little area suitable for significant alluvial sediment storage. The Yampa River flows through the massive Weber Sandstone below River Mile 21 and, from here to the mouth, the canyon floor is wider and more conducive to sediment deposition.

The abundance of subaerial alluvial sediment in the Green River below the Lodore Ranger Station is less uniform than in the Little Snake or Yampa Rivers. The relative abundance of alluvial deposits varies from less-than 10, to over 80 percent of the visible channel boundary between the Lodore Ranger Station and the downstream end of the study reach at River Mile 194 (Figs. 1 and 3C). The regional structural geology and lithology at river level may be significant in determining variations in canyon-floor width and gradient which influence the relative abundance of alluvial deposits in the Green River.

Sediment data from five sites in the Yampa River basin and the upper Green River basin have been collected by the USGS during an ongoing, multi-year study that began in 1998. These data were augmented with sediment data gathered at these sites in earlier years as part of other USGS studies and routine data collection activities. The sampling sites are:

1) Yampa River above Little Snake River, near Maybell, Colorado, 09251100,
2) Little Snake River, near Lily, Colorado, 09260000,
3) Yampa River at Deerlodge Park, 09260050,
4) Green River above Gates of Ladore, Colorado, 404417108524900 (nearest streamflow gage, Green River near Greendale, Utah, 09234500), and
5) Green River near Jensen, Utah, 09261000.

The period of record, number of samples, and type of sediment analyses vary at each of the sites. Suspended-sediment discharge was measured for all years at all of the sites. Bedload discharge was measured during a part of the period of record at four of the five sites. Sediment load by particle size-range and by hydrograph season also were measured for part of the record at all sites.

Sediment transport curves were derived by least-squares regression of logarithmic-transformed data to provide a means to estimate seasonal and annual sediment supply to the principal streams in the upper part of the watershed (the Yampa River, the Little Snake River, and the Green River above Gates of Ladore) and on the Green River just upstream from a critical spawning habitat near Jensen Utah. These transport curves can be revised as additional data from the ongoing sampling program become available.

One objective of this study is to identify future data needs for improving the accuracy of the sediment transport relations and sediment budgets at the five sampling sites. The relative accuracy and representativeness of the transport relations derived in this study can be assessed on the values of the coefficients of determination (R^2) of regression equations, the range of typical discharges sampled, the seasonality of the relations, and the sample size. The transport equations in this report are considered to be reasonably representative if the R^2 value is greater than about 0.70, if sediment samples are evenly distributed over the likely range of streamflow discharges in a year, if the samples are distributed between the rising- and falling-hydrograph seasons, and if the number of samples is large enough to reflect the variance in the sediment-load vs water-discharge relation.

The sediment transport equations presented in this report indicate that gravel, sand, silt and clay transport in these rivers is strongly dependent on the streamflow magnitude, and to a lesser degree, on the season. The timing of annual runoff, and consequently the timing of sediment entrainment, transport, and deposition, affects aquatic habitat and is dependent on climate and weather patterns and on the operation of upstream reservoirs. Reach-specific estimates of the timing, volume, and particle size of sediment deposited at critical aquatic habitat sites other than at the gaged sampling sites requires streamflow-routing through the drainage network and are beyond the scope of this report.

Yampa River above Little Snake River, near Maybell, Colorado, 09251100

The relatively large R^2 values for all transport equations at station 09251100 suggest that the transport equations may be useful for annual load estimation or sediment budget calculations; however, the small sample size may not reflect the population variance. Many of the sediment measurements were clustered in the discharge range from about 4,000 to 10,000 ft^3/s (Fig. 6). Consequently, these transport equations may not adequately reflect transport conditions of moderate-level discharges (e.g., in the 1,000 to 4,000 ft^3/s range) or of higher discharges as occurred in 1997. Additional measurements in the 1,000 to 4,000 ft^3/s range from both the rising- and falling-hydrograph seasons and above about 10,000 ft^3/s would make these equations more representative of flow conditions at this site.

Little Snake River, near Lily, Colorado, 09260000

The sediment measurements at station 09260000 are relatively evenly distributed over streamflows from about 50 to 6,000 ft^3/s; however, streamflows at conditions approaching the 1984 historic instantaneous peak discharge have not occurred in recent years. The transport equation for suspended-sediment load probably is adequate for estimating annual suspended loads in all years except when extremely high discharges occur. Although the distribution of data suggest a seasonal sediment-load hysteresis may exist, the relatively low R^2 values for the hydrograph seasons could be improved with additional data collected in the appropriate seasons. Also, since bedload data have not been collected at this site, neither the total-annual sediment load, nor the relative portion of total -sediment load transported as bedload are known. This is an important component of the annual sediment budget that should be quantified with future measurements.

Yampa River at Deerlodge Park, 09260050

The recent effort to collect sediment data at Deerlodge Park has increased the sample size of suspended sediment measurements by 124 percent and has increased the sample size of total sediment (suspended sediment plus bedload sediment) measurements by 58 percent since the 1980's. Based only on the relative magnitudes of the R^2 value, the additional data have resulted in a slightly improved suspended sediment transport equation (0.82 vs 0.76) and a slightly deteriorated total load equation (0.75 vs 0.79). Additional data collection may not improve these transport equations; however, more bedload measurements made during streamflows of less than about 900 to 1,000 ft^3/s could improve the accuracy of both the bedload-transport and total-sediment transport equations. Additional data collection during the rising and falling hydrograph periods might improve the transport equations that describe seasonality

Green River above Gates of Ladore, Colorado, 404417108524900

Sediment-transport equations for total-sediment load, suspended-sediment load, silt and clay load, and sand and gravel load had R^2 values greater than 0.78 (Table 12); however, the equation for bedload had an R^2 value of only 0.42. The seasonal transport equations had R^2 values greater than 0.81, but were based on small samples and, therefore, may not accurately reflect true seasonal conditions. Many of the sediment measurements were clustered in the streamflow range between about 4,500 and 10,000 ft^3/s (Fig. 9). Consequently, although most R^2 values are high, the equations may not adequately reflect moderate-level discharges (e.g., 2,500 to 4,500 ft^3/s). Additional sediment measurements made in the 4,500 and 10,000 ft^3/s range and in both early and late hydrograph seasons could improve the accuracy of the transport equations.

Green River near Jensen, Utah, 09261000

Sediment-transport equations for total-sediment, suspended-sediment, and transport by all particle sizes except very coarse sand and gravel had R^2 values greater than 0.70. The equation for bedload transport had an R^2 value of 0.46 and the equation for very coarse sand and gravel had an R^2 value of 0.54. Rising- and falling-season equations had R^2 values of 0.81 and 0.75, respectively, but these equations were based on relatively small samples and could be improved with more data. Most of the sediment data were collected at streamflows between about 5,500 and 22,000 ft^3/s and only three measurements were made at streamflows between 1,770 and 3,360 ft^3/s. The representativeness of all transport equations at this site could be improved with additional sediment measurements in the range of about 2,000 to 5,500 ft^3/s. The suspended-sediment transport equation derived from the 30 measurements made since 1996 has a significantly different slope and intercept than the equation derived by Andrews (1986) and, based on the R^2 value, a lesser variance. Resolution of these differences is another justification for making additional sediment measurements at the Jensen site.

VII. Recommendations:

Based upon peer review comments the work should be continued on for several years until sufficient data is collected to fill gaps in sediment rating tables and address issues raised in the draft report. For example, some data set which have a low R^2 because samples were gathered from a limited discharge range (e.g., only near the peak); improvement could be made by future sampling at other discharges.

VIII. Project Status: Ongoing and on-track; the current study runs from 1998 to 2001.

IX. FY 2001 Budget Status:

A. Funds Provided: $45,000
B. Funds Expended: $45,000
C. Difference: $ 0

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The USGS has provided $25,000 of match for this project to do additional analysis and correlation with data collected earlier in the century.

X. Status of Data Submission:

A review draft report is available and was sent to the Geomorphology Peer Review panel and ten other knowledgeable Recovery Program participants for comments. To date the comments have been constructive and positive. The review process will be competed in mid February 2002 and a final USGS Water-Resource investigation should be completed by December 2002.

XI. Signed: *George Smith*, for John Elliot — December 20, 2001
Principal Investigator — Date

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